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(54) OSCILLATORY GYRO AND TEMPERATURE DRIFT ADJUSTING METHOD THEREFOR

(57)Abstract:

PROBLEM TO BE SOLVED: To obtain an oscillatory gyro with a smaller temperature drift inexpensively with a simple circuitry.

SOLUTION: The oscillatory gyro 10 contains an oscillator 12 and an oscillation circuit 30 for exciting the oscillator 12. A terminal for detection of the oscillator 12 is connected to the ground through load resistances 26 and 28 while being connected to a differential circuit 32 and an output signal of the differential circuit 32 is detected with a synchronous detection circuit 34. An output signal of the synchronous detection circuit 34 is smoothed by a smoothing circuit 36 and further amplified with an amplification circuit 38. The resistance values of the load resistance 26 and 28 are adjusted according to the degree of the inclination of the temperature drift of the oscillatory gyro 10 to minimize the degree of the inclination of the temperature drift.

CLAIMS

[Claim(s)]

[Claim 1]A vibrator which has the detection terminals for taking out an electric charge generated when Coriolis force is appliedLoad impedance for being connected to an oscillating circuit for vibrating said vibrator and said detection terminals of said vibrator and transforming said electric charge into voltageAnd a digital disposal circuit which processes an output signal from said detection terminals of said vibrator and to which a signal corresponding to the angular rate of rotation is made to output is includedA temperature drift adjustment method of a vibration gyroscope which minimizes said temperature drift tilting amount by adjusting said load impedance according to a temperature drift tilting amount which shows change of output voltage from said digital disposal circuit to a temperature change.

[Claim 2]A temperature drift adjustment method of the vibration gyroscope according to claim 1 with whichas for said vibratorsaid load impedance is connected to each of said detection terminals including said at least two detection terminalsand a relation of an impedance value of said at least two load impedance is adjusted.

[Claim 3]A vibration gyroscope to which a temperature drift was adjusted by a temperature drift adjustment method of the vibration gyroscope according to claim 1 or 2.

DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Field of the Invention]This invention about a vibration gyroscope and a temperature drift adjustment method for the sameThe system which performs behavior detection of a mobile by detecting the angular rate of rotation especiallyfor exampleOr it is related with the vibration gyroscope applied to vibration removal systemssuch as a shaking hand arrester which detect the angular rate of rotation by external vibration of the navigation system which detects the position of a mobile and performs suitable derivationor a shaking handand performs proper dampingetc.and its temperature drift adjustment method.

[0002]

[Description of the Prior Art]Drawing 10 is an illustration figure showing an example of the conventional vibration gyroscope. The vibration gyroscope 1 contains the vibrator 2. The vibrator 2 contains the vibration body 3 of the Shozo prismatic formfor example. The piezoelectric elements 4a4band 4c are formed in three sides of the vibration body 3respectively. An electrode is formed in both sides of this piezoelectric layer including the piezoelectric layer which these piezoelectric elements 4a4band 4c becomefor example from porcelain. And one electrode of the piezoelectric elements 4a4band 4c pastes the side of the vibration body 3.

[0003]The oscillating circuit 5 is connected between the piezoelectric elements 4a and 4b and the piezoelectric element 4c. And the output signal from the piezoelectric element 4c returns to the oscillating circuit 5and the driving signal acquired by phase correction being amplified and carried out here is given to the piezoelectric elements 4a and 4b. With this driving signalflexing vibration of the vibration body 3 is carried out to the direction which intersects perpendicularly with a piezoelectric element 4c forming face.

[0004]The two piezoelectric elements 4a and 4b are connected to a digital disposal circuit. A digital disposal circuit comprises the differential circuit 6the synchronous detection circuit 7the smoothing circuit 8the amplifying circuit 9etc. And the piezoelectric elements 4a and 4b are connected to the input edge of the differential circuit 6. The outgoing end of the differential circuit 6 is connected to the synchronous detection circuit 7. In the synchronous detection circuit 7the output signal of the differential circuit 6 is detected synchronizing with the signal of the oscillating circuit 5. The synchronous detection circuit 7 is connected to the smoothing circuit 8and the smoothing circuit 8 is further connected to the amplifying circuit 9.

[0005]In this vibration gyroscope 1the vibration body 3 carries out flexing vibration to the direction which intersects perpendicularly with a piezoelectric element 4c forming

face by the oscillating circuit 5. At this time since the output signal of the piezoelectric elements 4a and 4b is the same from the differential circuit 6 the signal of the piezoelectric elements 4a and 4b is not outputted. In this state if the axis of the vibration body 3 is rotated as a center the vibrating direction of the vibration body 3 will change by Coriolis force. Thereby between the piezoelectric element 4a and 4b the difference of an output signal arises and a signal is outputted from the differential circuit 6. The output signal of the differential circuit 6 is detected in the synchronous detection circuit 7 and after smoothness is carried out further in the smoothing circuit 8 it is amplified in the amplifying circuit 9. Since the output signal of the differential circuit 6 supports change of the vibrating direction of the vibration body 3 if the output signal of the amplifying circuit 9 is measured it can detect the angular rate of rotation added to the vibrator 2.

[0006] In such a vibration gyroscope 1 at the time of nonrotation the vibrator 2 is formed so that the signal which serves as reference voltage near 25 ** may be outputted but there is a temperature drift in the output signal of the vibrator 2 or a digital disposal circuit and an output signal changes with ambient temperature. It is possible to consider it as circuitry which null voltage (drift component) does not generate as a method of suppressing such a temperature drift. The voltage of the self by which signal processing was carried out to the generated null voltage is subtracted and added and there is the method of canceling a temperature drift as shown in JP7-91957A. Temperature characteristics are given to the gain of a digital disposal circuit the temperature drift ingredient of a vibration gyroscope is canceled using the gain temperature characteristics and there is a method of obtaining a desired temperature drift as shown in JP2000-171258A.

[0007] As the circuit shown in JP7-91957A is shown in drawing 11 the signal outputted from the two piezoelectric elements 4a and 4b of the vibrator 2 is inputted into the differential amplifying circuit 6 and the output signal of the differential amplifying circuit 6 is inputted into the two synchronous detection circuits 7a and 7b. Although the output signal of the differential amplifying circuit 6 is detected in one synchronous detection circuit 7a like the vibration gyroscope shown in drawing 10 synchronizing with the signal with which about 90 degrees of phases differ from the synchronized signal in the synchronous detection circuit 7a the output signal of the differential amplifying circuit 6 is detected in the synchronous detection circuit 7b of another side. Thus from one synchronous detection circuit 7a a part for the amplitude difference of the drift components is outputted and a part for the phase contrast of the drift components is outputted from the synchronous detection circuit 7b of another side. And although null voltage is canceled by taking the difference of these drift components the temperature compensation circuit is provided so that these drift components may be mostly in agreement.

[0008] As the vibration gyroscope shown in JP2000-171258A is shown in drawing 12 in a circuit as shown in drawing 10 gain temperature-characteristics setting out is made so that it may have a temperature drift contrary to the temperature drift of a vibrator and offset control is made. As shown in drawing 13 the signal which has almost fixed offset voltage is outputted irrespective of change of temperature by it. The output at the time of nonrotation can be easily doubled with the value of request such as reference voltage or $V_{dd}/2$ by using the 2nd offset adjustment circuit.

[0009]

[Problem(s) to be Solved by the Invention] However when it is going to make it a circuit

which the null voltage of a vibrator does not generatesince the generation factor of null voltage is complicatedthe circuitry for canceling it will also become very complicated. There are many circuits added in a vibration gyroscope as shown in drawing 1 and since a temperature drift ingredient occurs also from these circuitsit is difficult to oppress the temperature drift ingredient of the whole vibration gyroscope. In the case of the vibration gyroscope which gave temperature characteristics to the gain of the digital disposal circuitcircuitry is comparatively easybut. after making offset voltage into about 1 lawin order to shift offset voltage so that a temperature drift may be made smalloffset control must be performed againand two offset control circuit parts are needed. Thereforean adjusting process becomes complicated and is not so preferred.

[0010]Sothe main purpose of this invention is easy circuitryand is providing the small vibration gyroscope of a temperature drift cheaply. The purpose of this invention is to provide the temperature drift adjustment method which can obtain the above vibration gyroscopes.

[0011]

[Means for Solving the Problem]A vibrator which has the detection terminals for taking out an electric charge generated when this invention requires Coriolis forceAn oscillating circuit for vibrating a vibratorand load impedance for being connected to detection terminals of a vibrator and transforming an electric charge into voltageA digital disposal circuit which processes an output signal from detection terminals of a vibrator and to which a signal corresponding to the angular rate of rotation is made to output is includedIt is a temperature drift adjustment method of a vibration gyroscope which minimizes a temperature drift tilting amount by adjusting load impedance according to a temperature drift tilting amount which shows change of output voltage from a digital disposal circuit to a temperature change. In a temperature drift adjustment method of such a vibration gyroscopeincluding at least two detection terminalsload impedance is connected to each of detection terminalsandas for a vibratorda relation of an impedance value of at least two load impedance is adjusted. This invention is the vibration gyroscope to which a temperature drift was adjusted by a temperature drift adjustment method of an above-mentioned vibration gyroscope.

[0012]When Coriolis force worksa temperature drift occurs with a value of element impedance of a vibrator which an electric charge generates. At this timea temperature drift can be adjusted by adjusting a value of load impedance connected to detection terminals of a vibrator. When there are two detection terminals in a vibratorda temperature drift can be adjusted by connecting load impedance to these two detection terminalsand adjusting a relation of such two load impedance. If such a method is adopteda temperature drift can be adjusted in an easy circuit and a cheap vibration gyroscope can be obtained.

[0013]The above-mentioned purpose of this inventionthe other purposesthe featureand an advantage will become still clearer from detailed explanation of the following embodiments of the invention given with reference to drawings.

[0014]

[Embodiment of the Invention]Drawing 1 is an illustration figure showing an example of the vibration gyroscope of this invention. The vibration gyroscope 10 contains the vibrator 12. As the vibrator 12as shownfor example in drawing 2some are bimorph type. This vibrator 12 contains the vibration body 18 which laminated the two tabular piezo

electric crystals 14 and 16. As shown in the arrow of drawing 2polarization of the piezo electric crystals 14 and 16 of each other is carried out for reverse. On the piezo electric crystal 14the electrodes 20a and 20b divided into two in the cross direction are formedand it is used as a terminal for detection for outputting the signal corresponding to Coriolis force. The whole surface on the piezo electric crystal 16the electrode 22 is formed and it is used as a terminal for excitation for carrying out flexing vibration of the vibration body 18.

[0015]As shown in drawing 3the vibrator 12 using the vibration body 24 of the Shozo prismatic form may be used. This vibration body 24 is formedfor example with materials which generally produce a mechanical vibrationsuch as an elinvaran iron nickel alloyquartzglasscrystaland ceramics.

[0016]The piezoelectric elements 26a26band 26c are formed in three sides of the vibration body 24respectively. An electrode is formed in both sides of this piezoelectric layer including the piezoelectric layer which these piezoelectric elements 26a26band 26c becomefor example from porcelain. And one electrode of the piezoelectric elements 26a26band 26c pastes the side of the vibration body 24. The two piezoelectric elements 26a and 26b are used as a terminal for detection for outputting the signal corresponding to Coriolis forceand other piezoelectric elements 26c are used as a terminal for excitation for carrying out flexing vibration of the vibration body 24.

[0017]The terminal for detection of the vibrator 12 is connected to a ground via the load resistance 26 and 28 as load impedancerespectively. In order that such load resistance 26 and 28 may transform into voltage the electric charge generated by vibration of the vibrator 12it is usedbut since it is used also as an object for temperature drift adjustmenta variable resistor etc. are used as the load resistance 26 and 28.

[0018]The terminal for detection of the vibrator 12 is connected to the input edge of the oscillating circuit 30. After the output signal from two terminals for detection of the vibrator 12 is added and phase correction of the oscillating circuit 30 is carried out including an adder circuitan amplifying circuitand a phase-shifting circuitit is amplified and a driving signal is formed. This driving signal is given to the terminal for excitation of the vibrator 12and the vibrator 12 vibrates. In this caseby the vibrator 12 shown in drawing 2the vibration body 18 carries out flexing vibration to the direction which intersects perpendicularly with the electrode 22 for excitationand the vibration body 24 carries out flexing vibration to the direction which intersects perpendicularly with an electrode 26c forming face by the vibrator 12 shown in drawing 3.

[0019]The terminal for detection of the vibrator 12 is connected to a digital disposal circuit. In a digital disposal circuitthe terminal for detection of the vibrator 12 is connected to the input edge of the differential circuit 32 including the differential circuit 32the synchronous detection circuit 34the smoothing circuit 36the amplifying circuit 38etc. The outgoing end of the differential circuit 32 is connected to the synchronous detection circuit 34. In the synchronous detection circuit 34the output signal of the differential circuit 32 is detected synchronizing with the signal of the oscillating circuit 30. The synchronous detection circuit 34 is connected to the smoothing circuit 36and the smoothing circuit 36 is connected to the amplifying circuit 38.

[0020]Vibration is excited by the oscillating circuit 30 in such a vibration gyroscope 10. For exampleflexing vibration is excited in the vibrator 12 as shown in drawing 2 or drawing 3. Since the same signal is outputted from two terminals for detection at this

time the signal of the terminal for detection is not outputted from the differential circuit 32. In this state if the angular rate of rotation is added to the vibrator 12 the vibrational state of the vibrator 12 will change a difference will arise to the signal outputted from two terminals for detection and a signal will be outputted by Coriolis force from the differential circuit 32. The output signal of the differential circuit 32 is detected in the synchronous detection circuit 34 and after smoothness is carried out further in the smoothing circuit 36 it is amplified in the amplifying circuit 38. Since the output signal of the differential circuit 32 supports change of the vibrational state of the vibrator 12 if the output signal of the amplifying circuit 38 is measured it can detect the angular rate of rotation added to the vibrator 12.

[0021] In such a vibration gyroscope 10 it is formed so that the signal which serves as reference voltage near 25°C may be outputted at the time of nonrotation but there is a temperature drift in the output signal from the vibrator 12 or a digital disposal circuit and as shown in drawing 4 an output signal changes with ambient temperature. Let change (ΔV) of the output voltage from the digital disposal circuit to a temperature change (ΔT) be a temperature drift tilting amount ($\Delta V/\Delta T$) in drawing 4. If the resistance of the load resistance 26 and 28 is made into R_L and R_R respectively when the resonance characteristic of two elements of the vibrator 12 has gathered as shown in drawing 5 when a temperature drift tilting amount is set to 0 at the time of $R_L=R_R$ and the difference between R_L and R_R becomes large a temperature drift tilting amount also has the relation of becoming large.

[0022] That is when the resonance characteristic of the element of the vibrator 12 is almost the same as shown in drawing 6 both impedance Z_L and Z_R also become almost the same. At this time both change is also the same as when as for the amplitude and the phase of voltage V_L outputted from two elements called for by the division ratio of Z and R and V_{Ra} set and temperature change mostly by making resistance R_L of the load resistance 26 and 28 and R_R into the same value. In this case a temperature drift is hardly generated but a temperature drift tilting amount is set to about 0.

[0023] However if the resistance of the load resistance 26 and 28 is made into $R_L=R_R$ when both impedance shifts for example like $Z_L>Z_R$ with manufacture dispersion etc. The amplitude of the detection voltage obtained by the division ratio of Z and R becomes $V_L < V_R$ phase contrast is also produced and the relation between a load resistance value and element impedance shifts. Therefore when ambient air temperature changes both amplitude and a phase change the detection phase to a synchronous detection signal changes and it appears as a temperature drift.

[0024] Then by making a load resistance value into $R_L>R_R$ when a difference arises in both impedance for example like $Z_L>Z_R$ in this vibration gyroscope 10 Amplitude of the detection voltage obtained by a division ratio can be made into $V_L > V_R$ and can also arrange a phase mostly. Therefore as shown in the sample A and the sample B of drawing 7 at the time of $Z_L>Z_R$. A temperature drift tilting amount can be set to 0 by considering it as $R_L>R_R$ and when it is $Z_L<Z_R$ a temperature drift tilting amount can be set to 0 by considering it as $R_L<R_R$.

[0025] Since the equivalent circuit of impedance Z_L of the element of the vibrator 12 and Z_R comprises resistance a capacitor and an inductor as shown in drawing 8 a load resistance value cannot only be changed and the inclination of a temperature drift cannot be made into the minimum only by arranging amplitude and a phase. Then a temperature drift

tilting amount can serve as the minimum by computing a tilting amount by measuring the temperature drift in $R_L=R_R$ following an experimental formula and performing final adjustment of R_L and R_R . Here an experimental formula shows the expression of relations of the temperature drift and load resistance value which are shown in drawing 5 or drawing 7.

[0026] In order to perform such adjustment the resistance of the load resistance 26 and 28 is adjusted but a temperature drift tilting amount can be adjusted by adjusting that trimming quantity by using trimming resistance as a variable resistor used as the load resistance 26 and 28 in this case.

[0027] Although the temperature drift of a vibration gyroscope is not adjusted in order to adjust null voltage the example which connected the variable resistor to one side of the detection terminals of a vibrator is shown in JP8-189834A. In this vibration gyroscope 1 as shown in drawing 14 one side of two detection terminals formed in the side of the cylindrical vibration body 3 is connected to a ground via a variable resistor and another side of two detection terminals is connected to a ground via fixed resistance.

[0028] In this vibration gyroscope 1 since the resistance connected to the detection terminals of the vibrator 2 is not used as input resistance to a differential amplifying circuit even if it adjusts null voltage by adjusting a variable resistor the detection sensitivity of a digital disposal circuit can be kept constant. However in such a vibration gyroscope 1 when forming a variable resistor by trimming resistance etc. resistance cannot be fluctuated but it can adjust only to one way. Therefore adjustment of null voltage also turns into adjustment of only one way. Therefore if manufacture dispersion of a vibratoretc. are taken into consideration trimming resistance is formed so that it may become the resistance from which null voltage shifts to one side greatly beforehand and it is necessary to adjust null voltage by performing trimming. Therefore it is necessary to adjust trimming resistance about almost all vibration gyroscopes.

[0029] To it in the vibration gyroscope 10 of this invention. Since the temperature drift is adjusted by adjusting the relation of the load resistance 26 and 28 connected to two detection terminals of the vibrator 12A temperature drift can be adjusted to both directions by adjusting either of the load resistance 26 and 28 like the sample A shown in drawing 7 and the sample B. Therefore it is not necessary to shift the resistance of the load resistance 26 and 28 greatly beforehand and the temperature drift of the vibration gyroscope 10 can be suppressed by easy adjustment.

[0030] Thus since adjustment of the temperature drift of the vibration gyroscope 10 can be performed by easy adjustment the load resistance 26 and 28 is constituted from a series circuit of fixed resistance and a variable resistor and it may enable it to tune it finely as shown in drawing 9. In this case even if it adjusts a variable resistor as the whole load resistance 26 and 28 resistance cannot change a lot but highly precise adjustment can be performed.

[0031] Although load resistance was used as load impedance in the vibration gyroscope 10 shown in drawing 1 or drawing 9 as long as it is an element which can transform into voltage the electric charge generated in the vibrator 12a capacitor or an inductor may be sufficient. If a temperature drift occurs even if it is things other than structure as shown in drawing 2 or drawing 3 as the vibrator 12 the art of this invention is applicable.

[0032]

[Effect of the Invention] According to this invention the circuit of easy composition can be

used it is cheap and moreover the small vibration gyroscope of a temperature drift can be obtained.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] It is an illustration figure showing an example of the vibration gyroscope of this invention.

[Drawing 2] It is a perspective view showing an example of a vibrator used for the vibration gyroscope shown in drawing 1.

[Drawing 3] It is a perspective view showing other examples of the vibrator used for the vibration gyroscope shown in drawing 1.

[Drawing 4] It is a graph for explaining the temperature drift tilting amount of a vibration gyroscope.

[Drawing 5] When two element impedance of a vibrator is equal it is a graph which shows a temperature drift tilting amount when the resistance of load resistance is made equal.

[Drawing 6] It is a representative circuit schematic showing the relation between the element impedance of a vibrator and load resistance.

[Drawing 7] When two element impedance of a vibrator has a difference it is a graph which shows the temperature drift tilting amount at the time of providing a difference in the resistance of load resistance.

[Drawing 8] It is a representative circuit schematic of the element impedance of a vibrator.

[Drawing 9] It is an illustration figure showing other examples of the vibration gyroscope of this invention.

[Drawing 10] It is an illustration figure showing an example of the conventional vibration gyroscope.

[Drawing 11] It is an illustration figure showing other examples of the conventional vibration gyroscope.

[Drawing 12] In the vibration gyroscope shown in drawing 10 it is a graph which shows the vibrator temperature drift and digital-disposal-circuit temperature characteristics at the time of giving temperature characteristics to the gain of a digital disposal circuit.

[Drawing 13] It is a graph which shows the output voltage obtained from the vibration gyroscope which has the characteristic shown in drawing 12.

[Drawing 14] It is an illustration figure showing the conventional vibration gyroscope for comparing with the vibration gyroscope of this invention.

[Description of Notations]

10 Vibration gyroscope

12 Vibrator

26 and 28 Load resistance

30 Oscillating circuit

32 Differential circuit

34 Synchronous detection circuit

36 Smoothing circuit

38 Amplifying circuit

